C2M Analysis on Select Channels with COM 4.5

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Overview

- **COM settings and configurations**
- **Highlights of Kareti and Weaver channels**
- **COM results at DER0=2E-5 with Eta0=1.25E-8**
  - Some results with DER0=2E-4
- **COM results with increasing PCB loss**
- **CR support**
- **C2M/CR loss budget**
- **Summary.**

Note of cautions: results provided here are based on just released COM 4.5Beta3 and this is work in progress.

COM Key Settings

- **Analysis is preliminary based on recently released COM 4.5Beta3**
  - COM C2M is work in progress
  - All results with MMSE local search taking ~5 min each
  - Compared to COM 4.3 results are ~0.1 to 0.25 dB better
- **Key COM parameters**
  - TX FFE configuration: 2 pre taps with one post, for configuration investigated pre/post taps were all 0
  - ASIC is 30 or 45 mm Package B (high loss)
  - CDR package 8 mm
  - Eta0=1.25E-8 (considering CK Eta0=4.1E-8, dj C2M Eta0 shouldn't be tighter than 1.25E-8)
  - DER0=2E-5, some results with DER0=2E-4
  - gDC≤5 dB with g_DC_HP≤5 dB, total CTLE gain was ~ 6 dB
  - DFE max tap =0.75 (did not reach max for any of the cases)
  - RX FFE configuration: 6 pre taps and with total of (25, 30, 35, 40, 45, 50, 55, and 60) FFE taps.

COM Config File

Table 93A-1 parameters			
Parameter	Setting	Units	Information
f_b	106.25	GBd	
f_min	0.05	GHz	
Delta_f	0.01	GHz	
C_d	[0.4e-4 0.9e-4 1.1e-4; 0.4e-4 0.9e-4 1.1e-4]	nF	[TX RX]
L_s	[0.13 0.15 0.14; 0.13 0.15 0.14]	nH	[TX RX]
C_b	[0.3e-4 0.3e-4]	nF	[TX RX]
R_d	[50 50]	Ohm	[TX RX]
R_0	50	Ohm	
PKG_NAME	PKG_HiR_CLASSB PKG_Module		TX RX
A_v	0.413	V	rqd syntx
A_fe	0.413	V	rqd syntx
A_ne	0.608	V	rqd syntx
L	4		
M	32		
filter and Eq			
f_r	0.55	*fb	
c(0)	0.65		min
c(-1)	[-0.3:0.02:0]		[min:step:max]
c(-2)	[0:.02:0.1]		[min:step:max]
c(-3)	0		[min:step:max]
c(-4)	0		[min:step:max]
c(1)	0		[min:step:max]
N_b	1	UI	
b_max(1)	0.75		As/dffe1
b_max(2..N_b)	1		As/dfe2..N_b
b_min(1)	0		As/dffe1
b_min(2..N_b)	-0.15	S	As/dfe2..N_b
g_DC	[-5:1:0]	dB	[min:step:max]
f_z	42.50	GHz	
f_p1	42.50	GHz	
f_p2	106.25	GHz	
g_DC_HP	[-5:1:0]		[min:step:max]
f_HP_PZ	1.328125	GHz	
Butterworth	1	logical	include in fr

I/O control		
DIAGNOSTICS	1	logical
DISPLAY_WINDOW	1	logical
CSV_REPORT	0	logical
RESULT_DIR	.\results\C2M_[date]\	
SAVE_FIGURES	0	logical
Port Order	[1 3 2 4]	
RUNTAG	C2M TP1a_COM_model	
COM_CONTRIBUTION	1	logical
Operational		
ERL Pass threshold	10	dB
COM Pass threshold	3	db
VEC Pass threshold	10.69073041	
DER_0	2.00E-05	
T_r	4.00E-03	ns
FORCE_TR	1	logical
Min_VEO_Test	0	mV
PMD_type	C2M	
T_O	50	mUI
samples_for_C2M	100	samples/UI
EW	0	
MLSE	0	
ts_anchor	1	
sample_adjustment	[-12 12]	
Local Search	2	
FFE_OPT_METHOD	MMSE	FV-LMS or MMSE
num_ui_RXFF_noise	1024	

Noise, jitter		
sigma_RJ	0.01	UI
A_DD	0.02	V^2/GHz
eta_0	1.25E-08	dB
SNR_TX	33	
R_LM	0.95	

Table 93A–3 parameters			
Parameter	Setting	Units	Information
package_tl_gamma0_a1_a2	[5e-4 0.00065 0.0003]		rqd syntx
package_tl_tau	0.006141	ns/mm	rqd syntx
package_Z_c	[92 92; 70 70; 80 80; 100 100]	Ohm	rqd syntx
z_p select	[4]		rqd syntx
z_p (TX)	[8 24 30 45 ; 1 1 11; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	rqd syntx
z_p (NEXT)	[8 8 8 8; 0 0 0 0 ; 0 0 0 0]	mm	rqd syntx
z_p (FEXT)	[8 24 30 45 ; 1 1 11; 1 1 1 1 ; 0.5 0.5 0.5 0.5]	mm	rqd syntx
z_p (RX)	[8 8 8 8; 0 0 0 0 ; 0 0 0 0]	mm	rqd syntx
C_p	[0.4e-4 0.4e-4]	nF	rqd syntx
Floating Tap Control			
N_bg	0	0 1 2 or 3 groups	
N_bf	4	taps per group	
N_f	120	UI span for floating taps	
bmaxg	0.2	max DFE value for floating taps	
B_float_RSS_MAX	0.1	rss tail tap limit	
N_tail_start	19	(UI) start of tail taps limit	
Filter: Rx FFE			
ffe_pre_tap_len	6	UI	
ffe_post_tap_len	18	UI	
ffe_pre_tap1_max	1	(normalized)	
ffe_post_tap1_max	1	(normalized)	
ffe_tapn_max	1	(normalized)	
TDR and ERL options			
TDR	1	logical	
ERL	1	logical	
ERL_ONLY	0	ns	
TR_TDR	0.01		
N	1000	logical	
TDR_Butterworth	1		
beta_x	0		
rho_x	0.618		
TDR_W_TXPKG	0	UI	
N_bx	20		
fixture delay time	[0 0]		
Tukey_Window	1		

SAVE_CONFIG2MAT	0	
Receiver testing		
RX_CALIBRATION	0	logical
Sigma BBN step	5.00E-03	V
ICN parameters		
f_v	0.588	Fb
f_f	0.278	Fb
f_n	0.278	Fb
f_2	58.438	GHz
A_ft	0.450	V
A_nt	0.450	V

Parameter	Setting	
board_tl_gamma0_a1_a2	*[0 6.44084e-4 3.6036e-05]*	1.4 db/in @ 53.125G
board_tl_tau	*5.790E-03*	ns/mm
board_Z_c	95	Ohm
z_bp (TX)	*125*	mm
z_bp (NEXT)	*125*	mm
z_bp (FEXT)	*125*	mm
z_bp (RX)	*0*	mm
C_0	[0 0]	nF
C_1	[0 0]	nF
Include PCB	0	logical
Seletions (rectangle, gaussian, dual_rayleigh, triangle		
Histogram_Window_Weight	gaussian	selection
Qr	*0.02*	UI

.START	PKG_LowR_CLASSA	[2.44 5.7] db

Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1_	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 92.5 92.5 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 24 30 45 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 24 30 45 ; 1.8 1.8 1.8 1.8 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.400
A_fe	[0.4057 0.4143 0.4143 0.4143]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

baseline
new
relevant for RxFFE
adjusted in experiment

59.03
59.03
106.25

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db

Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1_	[0.0005 0.00065 0.000293]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5; 95 95 ; 100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.400
A_fe	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

.START	PKG_Module		

Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1_	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
A_fe	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

.START	PKG_Null		

Issue with COM 4.5Beta3

.START	PKG_HiR_CLASSB	[2.8 5.6 6.7 9.4] db	
Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1_	[0.0005 0.00065 0.000293]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5; 95 95 ; 100 100; 78 78]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[12 24 30 45 ; 2 2 2 2; 1.3 1.3 1.3 1.3 ; 1.5 1.5 1.5 1.5]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.400
A_fe	[0.4049 0.4114 0.4132 0.4173]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

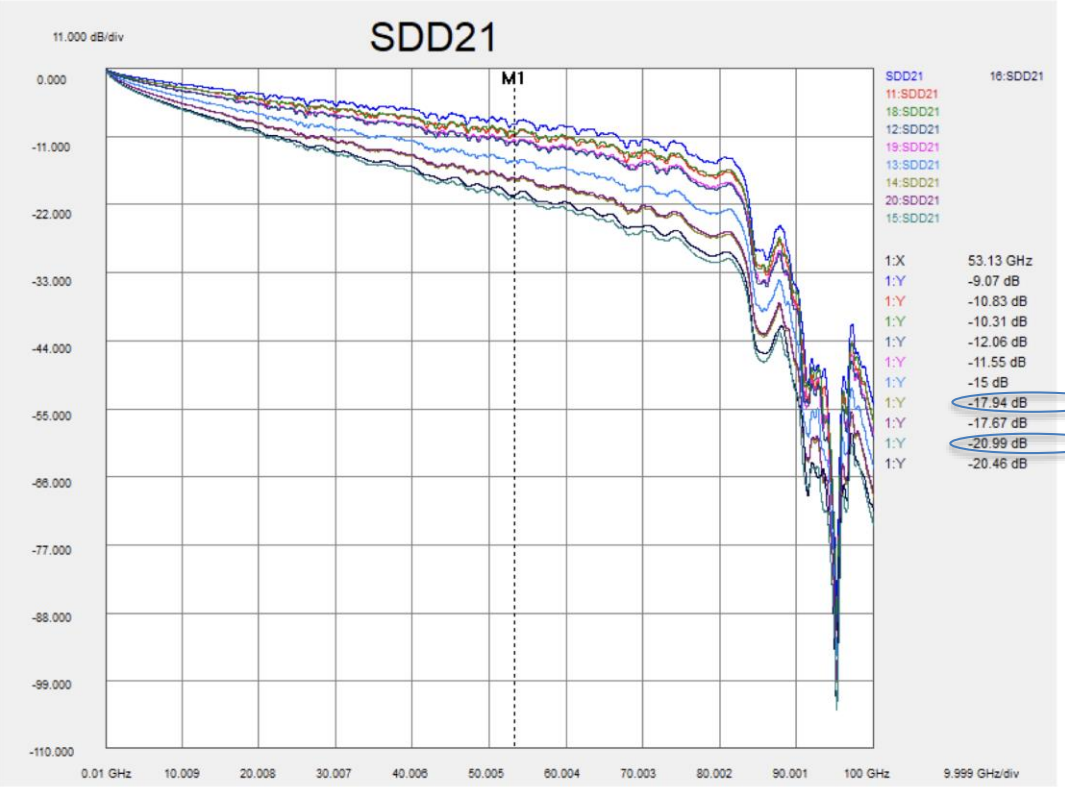
Identical

.START	PKG_Module		
Table 93A–3 parameters			
Parameter	Setting	Units	Information
ckage_tl_gamma0_a1_	[0.0005 0.00089 0.0002]		
package_tl_tau	0.006141	ns/mm	
package_Z_c	[87.5 87.5 ; 95 95 ; 100 100; 100 100]	Ohm	
R_d	[50 50]	Ohm	[TX RX]
z_p (TX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (NEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (FEXT)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
z_p (RX)	[8 8 8 8 ; 0 0 0 0 ; 0 0 0 0 ; 0 0 0 0]	mm	[test cases]
C_p	[0.4e-4 0.4e-4]	nF	[TX RX]
A_v	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.400
A_fe	[0.4057 0.4057 0.4057 0.4057]	V	Vf=0.399
A_ne	[0.45 0.45 0.45 0.45]	V	Vf=0.400
.END			

- **COM 4.5Beta3 doesn't read the NEXT parameters from the RX package**
  - If you have long package trace in the TX NEXT field then NEXT and contribution will be substantially lower
  - Depending on the case channel/package combination there could be ~0.2 dB less penalty reported for limited set of channel considered here
  - Short term workaround assuming ClassB PKG used for TX and Module PKG used for RX
    - Use identical TL parameters for PKG B and Module PKG
    - Copy z_p(NEXT) from Module PKG to ClassB PKG
    - Alternatively, don't use two package models
  - Results in this contribution correctly accounts for NEXT and would be somewhat more pessimistic because COM results include full impact of NEXT with the above workaround.

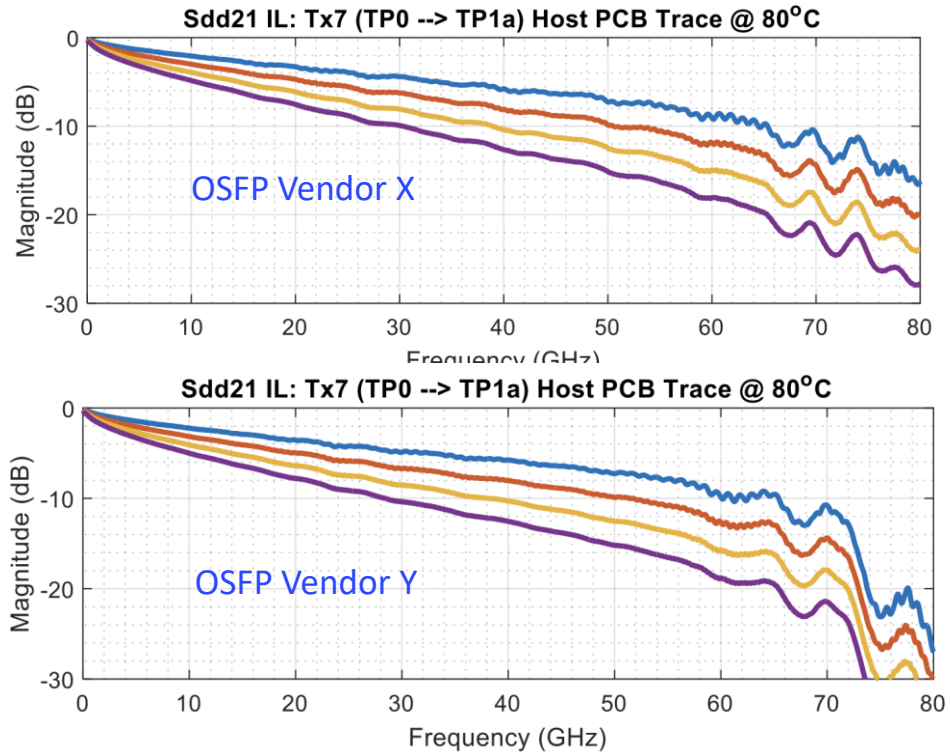
Channels for This Study

- **Kareti SL. No 8 and 10 channels higher loss used for the study**
- **Weaver 9” OSFP channels vendor X and Y used for the study**



SL. No 8

SL. No 10



Highlighted Channel Parameters for This Study

- **Key difference between Kareti and Weaver channels are:**
  - FOM ILD is much higher on Kareti channels
  - ICN is much higher on the Weaver OSFP vendor X channel.

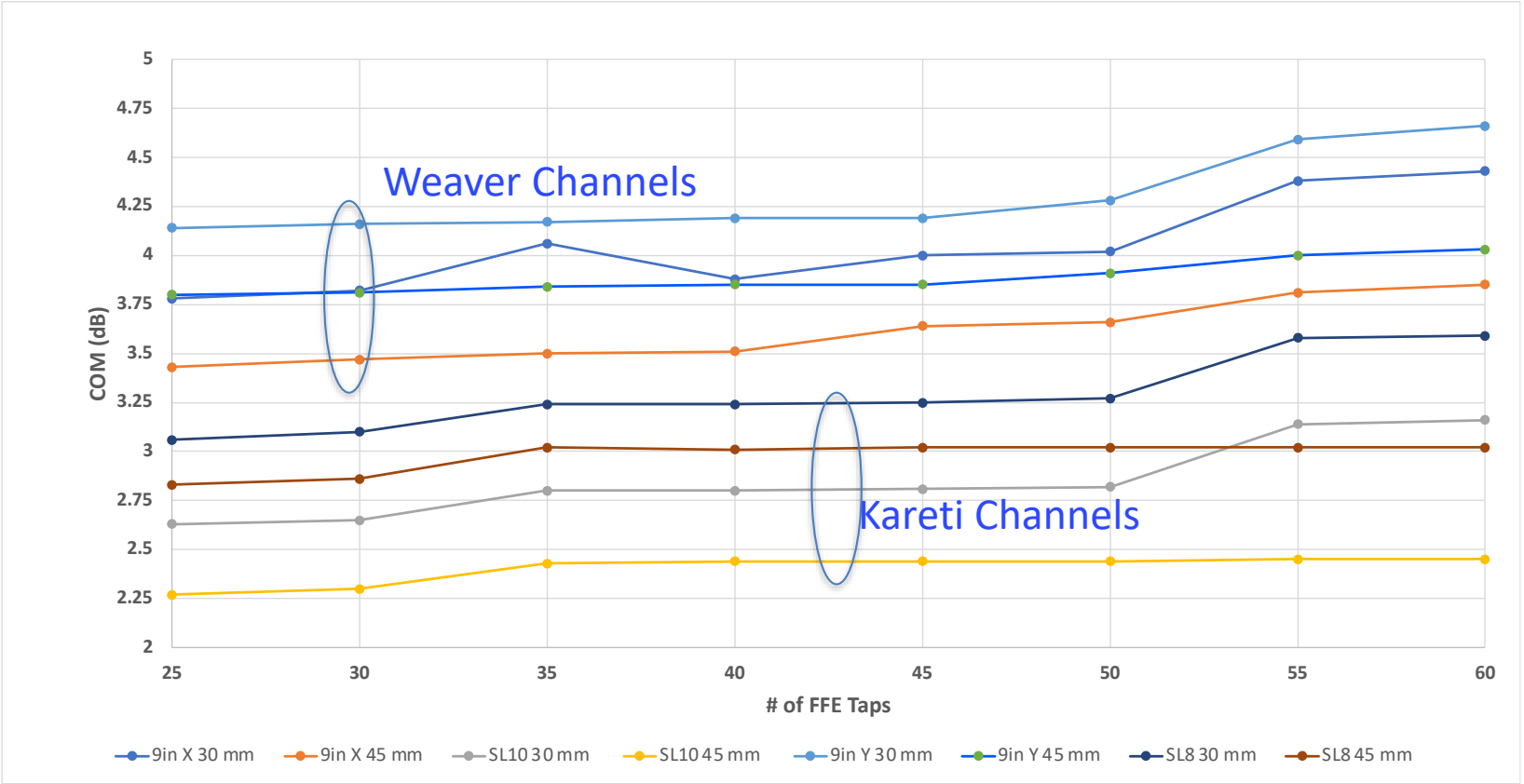
Channel	Trace Length (in)	Channel IL (dB)	ICN (mV)	FOM ILD	ERL11	ERL22	IL b-b with PKG B 30 mm+8mm CDR (dB)	IL b-b with PKG B 45 mm+8mm CDR (dB)
Kareti SL No 8	Unknown	17.9	1.37	0.147	16.8	15.9	26.4	29.1
Kareti SL No 10	Unknown	21.2	1.12	0.147	17.2	16.1	29.5	32.2
Weaver Vendor "X" OSFP Tx7	9	15.7	1.83	0.080	21.5	15.3	24.5	27.1
Weaver Vendor "Y" OSFP Tx7	9	16.1	1.03	0.074	21.8	15.8	24.6	27.2

COM Results

- **Results shown are with Eta0=1.25E-8, Eta0=6E-9 only improves COM by ~0.2 dB**
- **Kareti SL No 8 with 45 mm package passes 3 dB COM for ≥ 45 taps, Kareti No 10 with 45 mm package doesn't pass 3 dB COM even with 60 tap FFE**
  - Considering diminishing return increasing FFE taps, the higher loss Kareti channels require MLSE or terminating the FEC.

Kareti SL No. 8 and 10 Channels

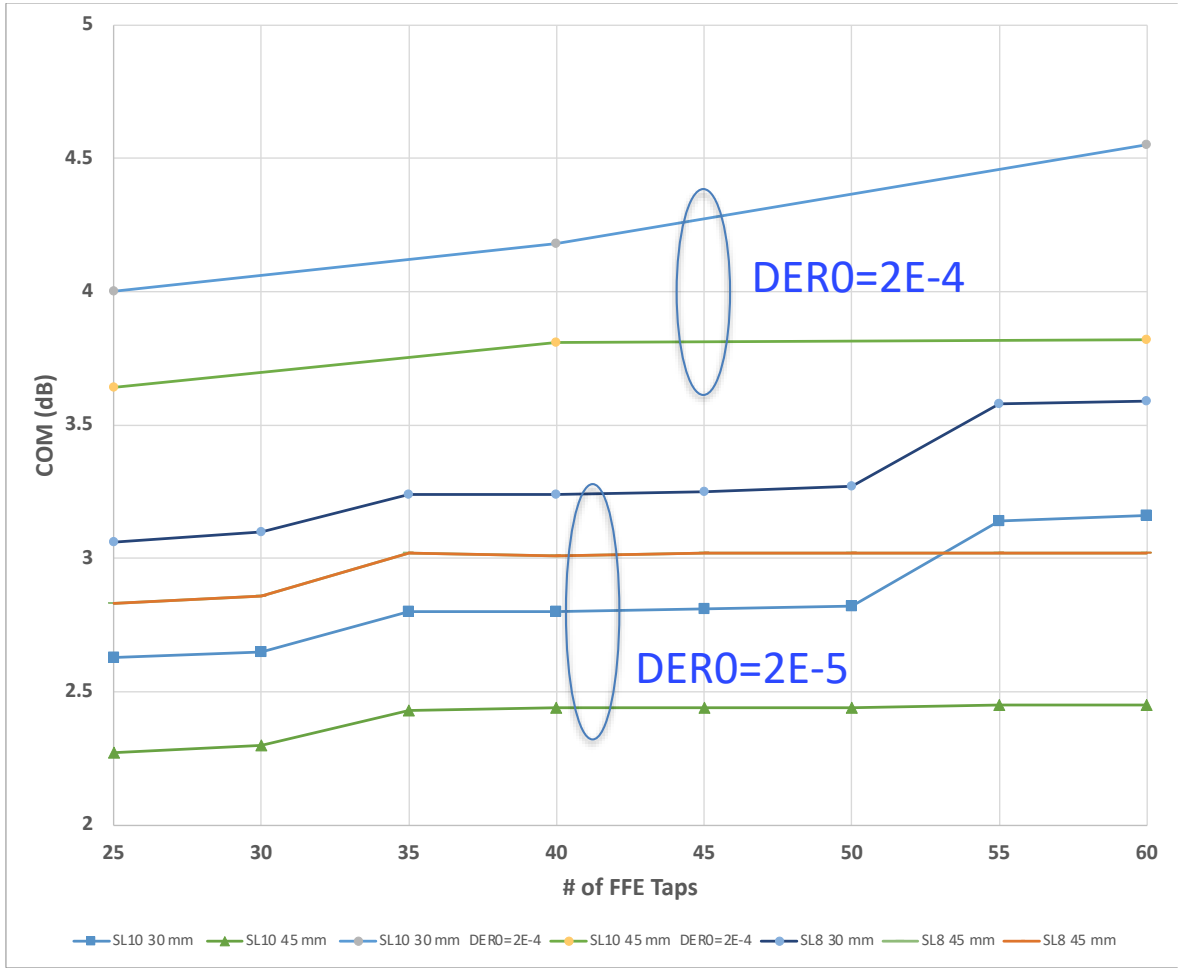
Weaver 9" OSFP with Connector X and Y



COM Results

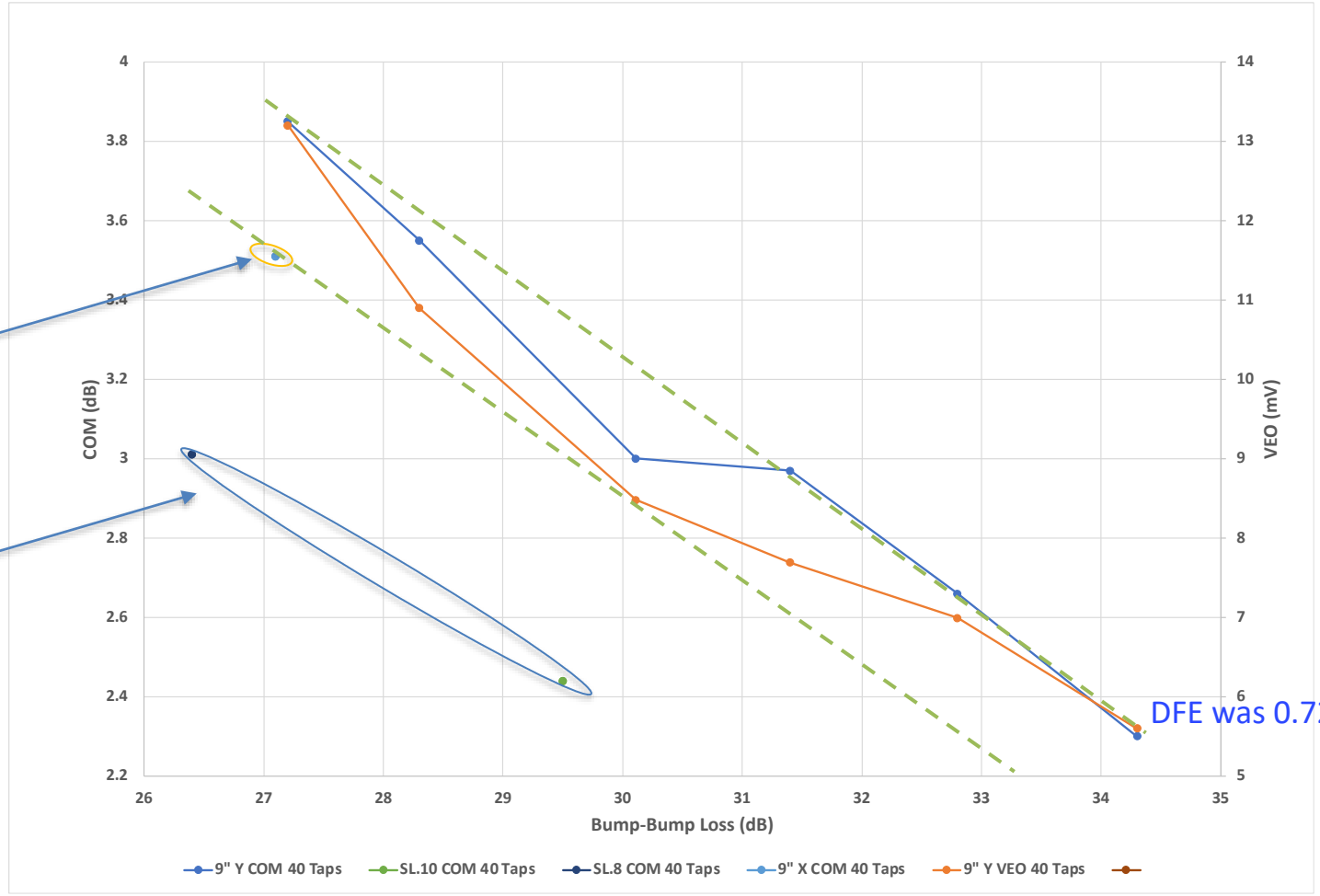
- **Kareti channel COM results with addition of results for Kareti SL No 10 channel at DER0=2E-4**
  - The more challenging Kareti channel SL No 10 with DER0=2E-4 has COM > 4 dB even with 25 taps FFE!

Kareti SL No. 8 and 10 Channels
All results are with Eta0=1.25E-8



Impact of Increasing Channel Loss on COM at DER 2E-5

- **Use one of the best channel the Weaver 9” with vendor Y OSFP (lower ICN) to study loss impact on COM by adding (25, 50, 75, 100, and 125 mm) PCB loss to the channel**
  - Even for the best Weaver channel 3 dB COM is at 31.2 dB loss with ~77% of penalties dominated by System Noise/Jitter accounting!



Weaver 9” vendor X OSFP
Without any added PCB

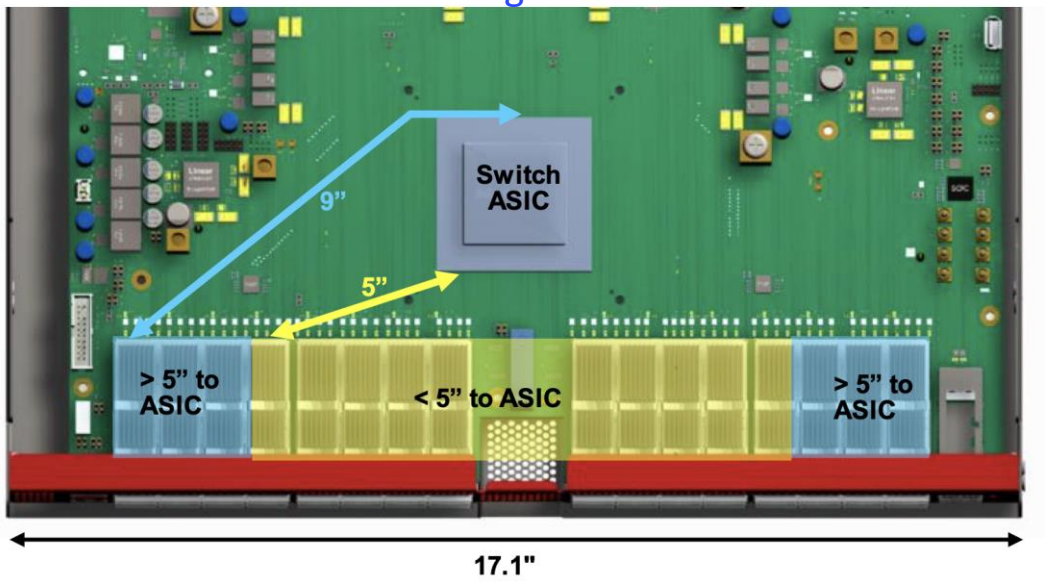
Kareti SL No. 8 and 10 Channels
Without any added PCB loss

DFE was 0.7233

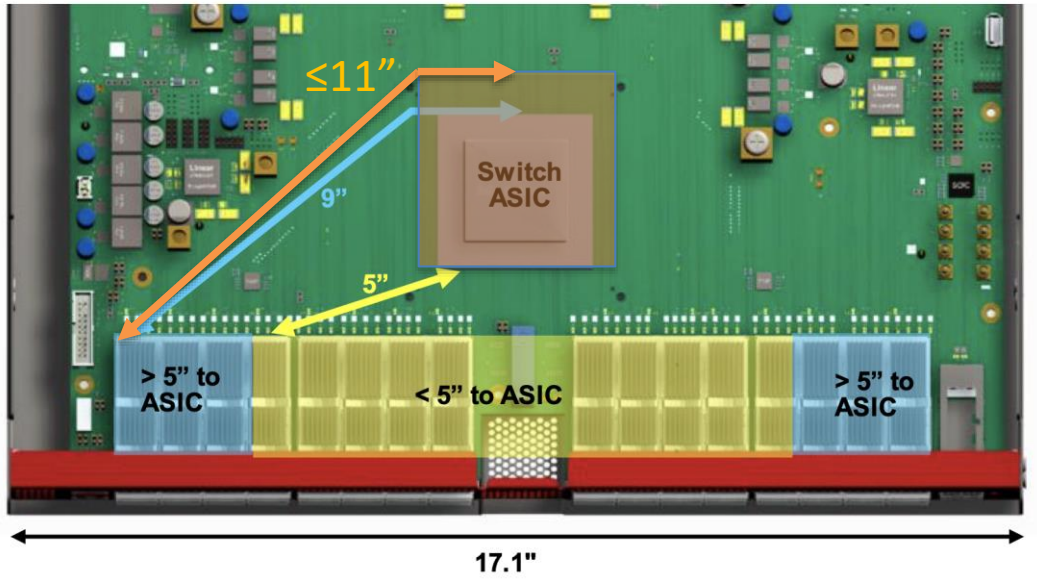
Revisiting C2M Application

- **In 802.3ck max C2M PCB length assumed was 9” per recommendation stone_3ck_01a_0518**
  - In CL120G max host PCB loss was only 11.9 dB with assumed PCB loss ~1.2 dB/in
  - weaver_3dj_elec_01_230831 C2M channels go up to 9” and was stated during Q&A the upper limit for 512 lane switch PCB length is <10”
    - Any application needing more than 10” has the option to use cabled host or retimers
  - PCB length of 10 ” expect to cover common 512 lanes C2M switch implementations!

Stone Hypothetical 256 Lane Switch
Package ~69x69



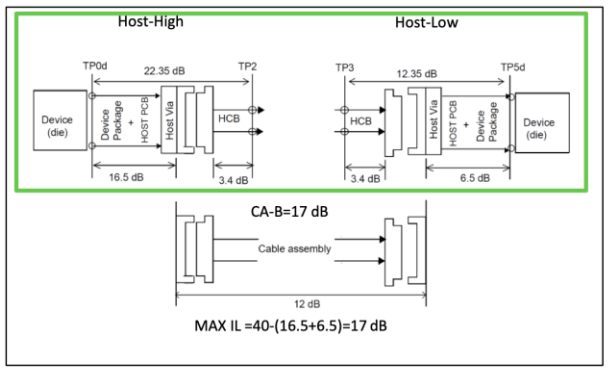
Hypothetical 512 lane (102T) Switch
Package ~90x90



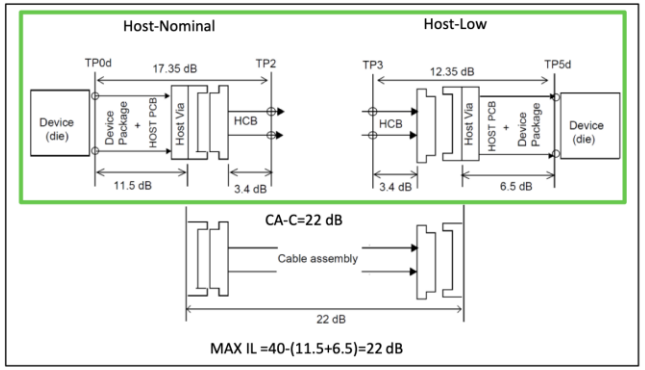
Half of the Switch Ports Must Support CR

- **A key takeaway from OFC 2024 was that Cu power is lowest and offer the lowest cost**
  - Near Margalit (Broadcom), Cu offer lowest power if meets the reach, OFC 2024 Rump Session
  - Mark Nowell (Cisco), Lowering Power for AI/Ml is critical and require maximizing Cu use in the rack, OFC 2024 DCS Panel II
  - Craig Thomson (NVidia), NVL72 Rack backplane based on 1.5 m passive Cu cable by maximizing single rack density with liquid cooling allow more nodes connected with Cu to lower PD, OFC 2024 DCS Panel I
- **Pushing C2M/VSR bump-bump loss >30 dB is a futile effort as such product unlikely to support CR on 50% of the ports and will not have broad market potential but will increase C2M/VSR power**
  - CR high loss port TP0d-connector loss must be ≤16.5 dB (TP0d-TP2≤22.35 dB) to support any Cu cable, see tracy_3dj_01a_2311.

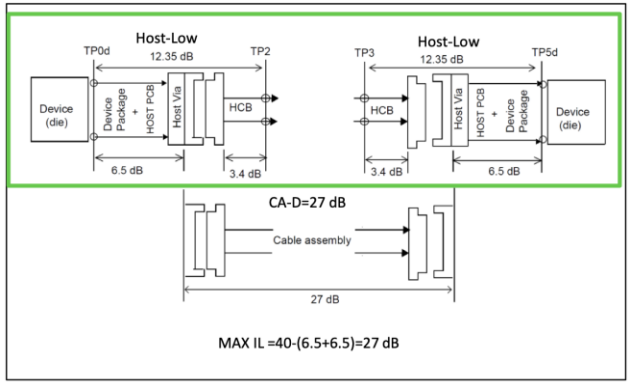
802.3 dJ CR Host and Cable Assembly Losses



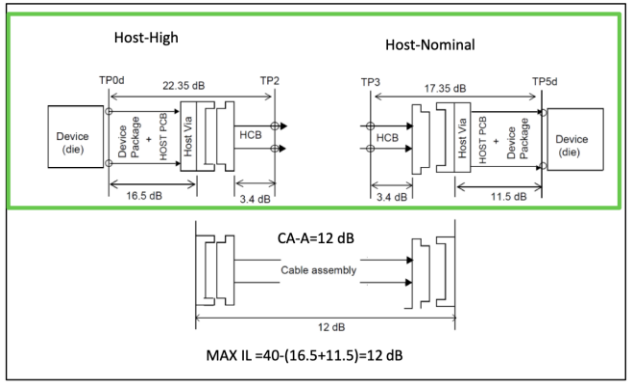
NOTE—The 16.5 dB and 6.5 dB ILdd



NOTE—The 11.5 dB and 6.5 dB ILdd



NOTE— 6.5 dB ILdd includes allowance for BGA and connector footprint vias.



NOTE—The 16.5 dB and 11.5 dB ILdd includes allowance for BGA and connector footprint vias.

Link Configurations IL (TX to RX)

Device Package + Host PCB	Host-Low 6.5 dB	Host-Nominal 11.5 dB	Host-High 16.5 dB
Host -Low 6.5 dB	CA-A,B,C,D	CA-A,B,C	CA-A,B
Host-Nominal 11.5 dB	CA-A,B,C	CA-A,B	CA-A
Host-High 16.5 dB	CA-A,B	CA-A	not supported

Cable Assembly	Insertion Loss Cable + 2*Connectors
CA-A	12 dB
CA-B	17 dB
CA-C	22 dB
CA-D	27 dB

Proposed baseline content

C2M Loss Budgets

- **Weaver 9” OSFP channels with package B (9.5 dB) have loss < 28 dB**
  - If one avoid connecting longest PCB trace to package trace then host PCB reach can be > 11”
- **The requirement to support CR on 50% of ports is much more challenging than limiting C2M loss to ≤28 dB**
  - Limiting C2M loss budget to 28 dB then it will also be aligned with the OIF EEI 224G-TRO half retime.

106 GBd PAM4	200G-C2M	200G-C2M	200G-C2M	200G-C2M	200G-CR Host-High
Channel IL C2M Bump-Bump (dB) Channel IL CR Bump-TP2 (dB)	28	30	32	34	22.35
TP0-TP1a IL (dB) Package A 33 mm (5 dB)	23	25	27	29	17.35
TP0-TP1a IL (dB) Package B 45 mm (9.5 dB)	18.5	20.5	22.5	24.5	12.85
Host PCB Loss (dB) Package A	16.4*	18.4*	20.4*	22.4*	11.5*
Host PCB Loss (dB) Package B	11.9*	13.9*	15.9*	17.9*	7*
Host PCB Length (in) Package A Assuming 1.4 dB/in	11.7 ✓	13.1 ✓	14.6 ✓	16 ✓	8.2
Host PCB Length (in) Package B Assuming 1.4 dB/in	8.5 ✓	9.9 ✓	11.4✓	12.8✓	5

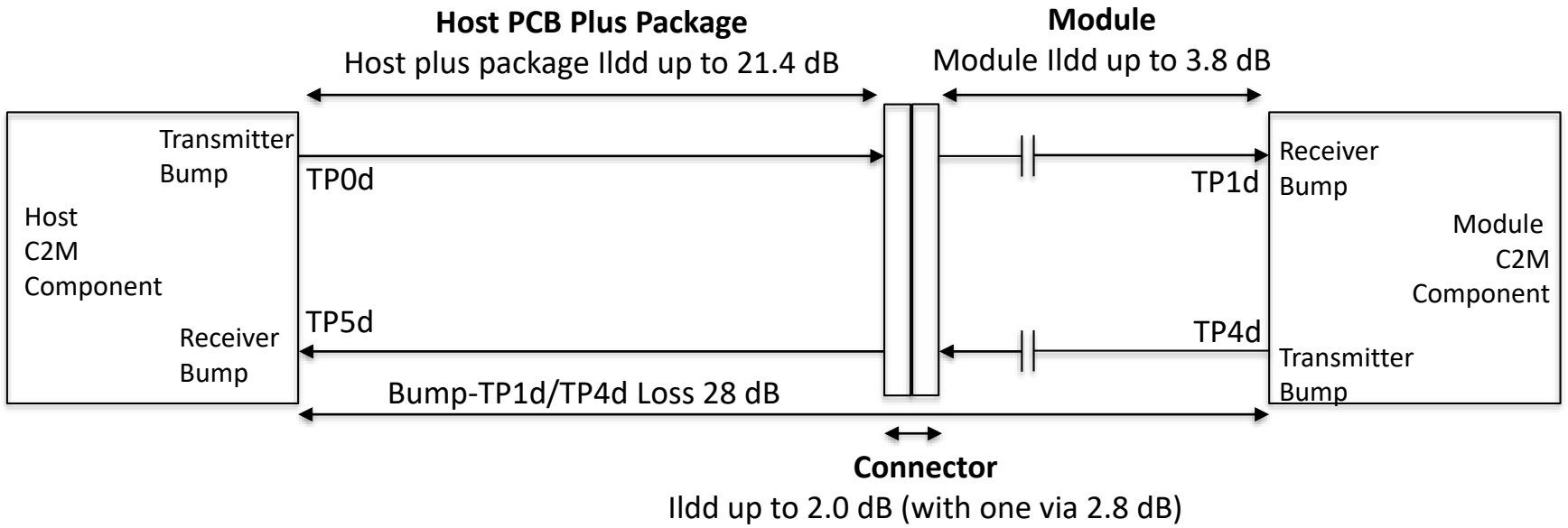
* Assumes connector loss=2 dB, HCB/Plug board loss=3.6 dB, 1 dB excess host via loss.

** CR High Loss of 16.5 dB was used to determine host PCB losses.

This is not the classic C2M Application!

AUI C2M Application Reference Model

- **AUI C2M total loss for DJ proposed to be from TP0d(bump) -TP1d**
  - Recommend to use TP0d for host ASIC Tx bump and TP1d for HCB output test point
  - Recommend to use TP5d for host ASIC Rx bump and TP4d for HCB input test point
  - C2M max bump-bump TP0d -TP1d (TP4d-TP5d) loss ≤ 28 dB at 53.125 GHz.



C2M Straw Proposal

- **Transmitter 4 tap FFE (pre/post taps are all zero with current COM code)**
  - C(0)min=0.65, C(-1)=[-0.2:0.02:0], C(-2)=[0:0.02:0.16], C(1)=[-0.16:0.02:0]
- **Receiver 25 tap FFE+ 1T DFE**
  - With up to 6 pre-cursor
  - DFE(max) ≤ 0.75
  - G_DC_HP ≤ -5 dB
  - G_DC ≤ -5 dB (generally zero)
  - Eta0=1.25E-8
- **Informative bump-bump channel loss ≤28 dB**
  - Exceeding 28 dB recommended loss budget is acceptable as long as TP1a VEO/VEC are compliant, and host tolerate TP4 signal
- **TP1a specifications with loss less than 30 dB and Eta0=1.25E-8 can remain based on VEO/VEC but EECQ is alternate option that require more investigation**
  - VEO ≥ 8 mV
  - VEC≤ 10.7 dB (COM= 3dB).

Summary

- **Some preliminary results from COM 4.5Beta3 with MMSE evaluating two sets of dj submitted C2M channels targeting 102.4T switches**
  - Compared to ghiasi_3dj_03a_2403 results with COM4.3, results from COM 4.5 are about 0.1-0.3 dB better
  - For channels evaluated TX FFE taps were all zero for nFFE+1TDFE receiver
- **C2M operating at DER0 of 2E-5 compared to KR at DER0 of 2E-4 adds about 2 dB of COM penalty**
  - As the loss increases > 30 dB at DER 2E-5 over 75% of penalties are due to noise and jitter so increasing equalizer length provide negligible improvement
  - Segmented FEC is best option for high loss channels
- **Solution space for practical FFE/DFE equalizers that operates at C2M DER0 of 2E-5 with > 30 dB of loss are limited**
  - Even Weaver OSFP vendor Y OSFP (ILD=0.074, ICN=1.03 mV) with added PCB loss starting failing ~32 dB
  - Weaver 9” channels with Package B (9.5 dB) has bump-bump loss of 27.2 dB, so is there a reason to go beyond 28 dB loss considering option of not connecting longest package trace to longest PCB trace exist
  - Considering strong demand to support CR with much more challenging loss budget on 50% of host ports there is no reason to push C2M loss >28 dB
- **Propose to adopt low power SerDes based on 25T-FFE/1TDFE reference receiver for C2M with informative bump-bump loss ≤28 dB**
  - With advances in PCB material, availability of high-volume material with DF<0.001, and HVLP4 foil with σ~0.5 μm, Weaver PCB loss of 1.4 dB/in loss at 70 ^{o}C can be reduced to 1 dB/in.

Contribution Addressing Following D1.0 Comments

- **Comments 130 – CL 176E Loss budget**
- **Comments 132 – CL 176E VEC/VEO**
- **Comments 134 – CL 176E loss at Nyquist**
- **Comments 138 – CL 176E TX FFE taps/range**
- **Comments 140 – CL 176E reference equalizer**
- **Comments 585 – CL 179A MCB loss.**
- **Comments 586 – CL 179A HCB loss.**